Sandia National Laboratories

National Spent Nuclear Fuel Program

Description

The U.S. Department of Energy (DOE) established the National Spent Nuclear Fuel Program (NSNFP) to support its need to safely and efficiently manage all DOE-owned spent nuclear fuel and prepare it for disposal. The NSNFP is addressing that need. The NSNFP mission is to provide technology solutions and guidance to ensure safe, efficient handling, characterization, and disposition of DOE-owned or managed spent nuclear fuel (SNF).

The NSNFP is currently performing analyses and providing technology solutions in four distinct areas of spent nuclear fuel management. Projects are related to the following focus areas:

- Solutions for safe, efficient packaging and transportation
- Solutions for safe, interim and long-term storage
- Solutions for accurate characterization
- Compliance with safety and regulatory requirements

Program Drivers

The Office of Spent Fuel Management was created to plan and coordinate the management of DOE-owned spent nuclear fuel. It was established as a result of a 1992 decision to stop spent nuclear fuel reprocessing and was chartered to safely and efficiently manage DOE-owned spent nuclear fuel and prepare it for disposal. The NSNFP is based upon numerous program drivers and must be managed in accordance with them. These drivers have origins in laws, regulations, policies, and agreements at the federal, state, and local levels. The drivers serve two purposes. They establish the structure in which the program must work to accomplish its goals, and they dictate what the program must do. The major program drivers are listed below.

- Federal laws
- Presidential Orders
- Nuclear Regulatory Commission regulations and guidance
- Environmental Protection Agency regulations
- Department of Transportation requirements
- DOE orders, policies, and guidance
- Defense Nuclear Facilities Safety Board recommendations
- Office of Environmental Management requirements
- State and local regulations and agreements

Sandia is a multiprogram laboratory operated by Sandia corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.
SAND2001-1229P

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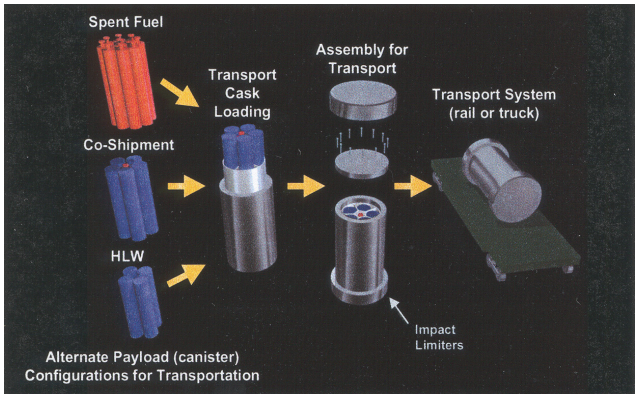
Sandia National Laboratories Involvement with NSNFP

Work has been conducted since the inception of the NSNFP at Sandia National Laboratories in conjunction with Idaho National Engineering and Environmental Laboratory (INEEL), the lead laboratory for NSNFP, to assist in the development of a safe, cost-effective technical strategy for the interim management and ultimate disposition of the foreign and domestic DOE spent nuclear fuel.



Transportation System Concept

Sandia NSNFP Task Descriptions

Features, Events, and Processes (FEP) Screening: Sandia has assisted the NSNFP in features, events, and processes screening for the DOE-owned spent nuclear fuels. The FY2000 work on FEP screening of DOE SNF was as follows: 1) Criticality Screening Argument Support – provide support to help complete the NSNFP Analysis/Model Report covering the screening of criticality FEPs for DOE SNF; 2) Provide interface support between the NSNFP FEP work, DOE radioactive waste (RW) FEP work, and Nuclear Regulatory Commission (NRC) reviews. This can also included support for input DOE SNF FEP information into the overall RW FEP database; 3) Complete screening arguments for 44 DOE SNF FEPs assigned to Sandia in support of the "waste form degradation" and "radionuclide mobilization" process model report.

EQ3/6 Calculations: Sandia assisted the NSNFP by providing calculation support using EQ3/6, a qualified chemical equilibrium code, for two fuel types in support of the phase II (degraded, in-package) criticality analysis. Sandia supported the efforts with RW and the Yucca Moutain Project management and the managing and operating company to analyze DOE SNF in the area of internal and external criticality. Part of this effort involved the calculation of geochemical reactions during waste package and fuel canister degradation.

Computer Model of Loaded Transportation Cask Drop

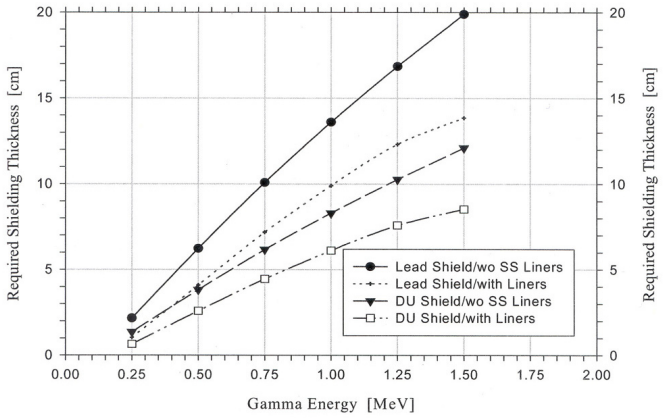
Safeguards: Sandia supported the determination of potential areas of proliferation vulnerability for DOE's Highly-Enriched Uranium (HEU) SNF and identified operations and features that represent potentially significant shortfalls from goals for proliferation resistance. The emphasis of the study was on DOE's lightly irradiated HEU SNF. The vulnerability study included the following key elements:
1) determination of quantities of HEU SNF, categories, attractiveness levels and physical form; 2) development of a frame work for proliferation resistance; 3) determination of vulnerabilities for theft and diversion of the SNF; 4) assessment of the proliferation vulnerability of various scenarios against the spent fuel standard; 5) identification of potential institutional issues.

Transportation: Sandia performed engineering analyses of the loaded transportation cask for drops without the impact limiters from a height of 72in onto an unyielding surface in the following orientations to determine if the design is adequate and failure will not occur:

1) on the lifting trunnion; 2) on the closure lip; 3) in a horizontal orientation onto a pin defined in 10 Code of Federal Regulations (CFR) 71.73, such that the pin impacts the cask at the midpoint along the cask's longitudinal axis; 4) on the bottom edge, assuming the point of impact to be opposite a longitudinal weld along the shell; 5) cask slap-down onto a hard, essentially unyielding surface with the trunnions making the initial contact.

Sandia also performed a review of the draft design specification and provided packaging engineering support.

Shielding Analyses: Preliminary shielding calculations were performed for a prototype NSNFP transport cask. This analysis is intended for use in the selection of cask shield material type and preliminary estimate of shielding thickness. The radiation source term was modeled as cobalt-60 with radiation exposure strength of 100,000 R/hr. Cobalt-60 was chosen as surrogate source because it simultaneously emits two high-energy gammas, 1.17 MeV and 1.33 MeV. This gamma spectrum is considered to be large enough that it will upper bound the spectra of all the various spent nuclear fuels types currently expected to be shipped within the prototype cask. Point-kernel shielding calculations were performed for a wide range of shielding thickness of lead and depleted uranium material. The computational results were compared to three shielding limits: 200 mrem/hr dose rate limit at the cask surface, 50 mR/hr exposure rate limit at one meter from the cask surface, and 10 mrem/hr limit dose rate at two meters from the cask surface. The results obtained in this study indicated that a shielding thickness of 8.5cm is required for depleted uranium and 14cm for lead in order to satisfy all three shielding requirements. The system analysis also indicated that required shielding thicknesses are strongly dependent upon the gamma energy spectrum from the radiation source term. This latter finding means that shielding material thickness, and hence cask weight, can be significantly reduced if the radiation source term can be shown to have a softer gamma energy spectrum than that due to cobalt-60.



Shielding Thickness Required for Cask Surface

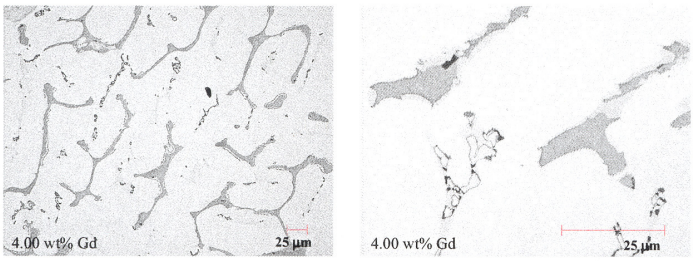
Canister Basket: The Office of Civilian Radioactive Waste Management conducted a review of the Managing and Operating contractor work on the frequency of drop, the breach of DOE SNF canisters, and the NSNFP canister design and testing. Based on this review, Sandia developed an estimate of the conditional probability breach for DOE SNF standardized canisters given a range of drop heights. This conditional probability was then combined with estimates of drop frequency to provide the frequency of drop and breach events. The results provided a referenceable technical basis for the proposed licensing strategy to assure that drop and breach of a canister is a beyond design basis event.

Licensing & Certification Working Group: Sandia supported the Office of Environmental Management (EM) in establishing licensing and certification strategies for DOE-owned SNF. This included: 1) review of analyses to help establish the licensing basis; 2) interface with RW in establishing acceptance criteria; 3) support of the Licensing and Certification Steering Committee; 4) input on DOE SNF characterization and certification based upon previous nondestructive analysis/nondestructive examination (NDA/NDE) evaluation and decision support tasks; 5) performance of supplemental analyses to provide direction and substantiation of positions EM may take; 6) support on development of characterization, licensing and certification strategies.

Repository Receipts Support: Sandia performed independent verification and validation of a computer tool used to analyze various shipping scenarios of EM material to the monitored geologic repository. Sandia assisted in the development of functional and operational requirements, quality assurance strategy, and provided general support in the development of the computer tool.

Gadolinium Alloy Development: Sandia has the lead role, in cooperation with Lehigh University and INEEL, to develop Gd-based alloys suitable for transportation and repository applications. These alloys will be used for internal structures ("baskets") in transport casks and repository waste packages. The Gd alloy addition provides criticality mitigation. The program involves basic metallurgy and welding engineering disciplines. Technical community acceptance of the alloys is being promoted through consensus standards organizations (ASM, AME).

Pilot heat microstructures - 4.00 wt% Gd



Micrograph of Gd/Stainless Steel Grain Structure

Spent Nuclear Fuel Canister Drop Test

Drop-test Program: Sandia successfully planned and conducted fully instrumented, quality assured drop tests of the NSNFP Standard Canister for DOE SNF to evaluate the integrity of the canisters under accident conditions.

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